MR Sept. 1942

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
September 19 1942 as
Memorandum Report

GENERALIZED SELECTION CHARTS FOR BOMBERS

POWERED BY ONE, TWO, FOUR, AND SIX 2000-HORSEPOWER ENGINES

I. CAPACITY AND ECONOMY

By Maurice J. Brevoort, George W. Stickle, and Paul R. Hill

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

MEMORANDUM REPORT

for the

Army Air Forces, Materiel Command

GENERALIZED SELECTION CHARTS FOR BOMBERS

POWERED BY ONE, TWO, FOUR, AND SIX 2000-HORSEPOWER ENGINES

I. CAPACITY AND ECONOMY

By Maurice J. Brevoort, George W. Stickle, and Paul R. Hill

INTRODUCTION

This paper is a continuation of the report entitled "Generalized Selection Charts for Bombers Powered by One, Two, Four, and Six 2000-Horsepower Engines" dated July 6, 1942.

This supplement uses the data presented in the original report to show the cargo which can be carried at various ranges, the pounds of cargo which can be carried for a pound of fuel, and other graphs which simplify the problem of quickly determining the cargo which can be carried at any range. The information as it is presented in the supplement is in a form that is more easily applied to the economic or tactical problems.

The assumptions, selected parameters, and equations applying to the original report apply without change to the supplement. The single-engine bomber is not treated in this supplement. It is assumed that the gasoline and bombs are completely interchangeable. This assumption requires that part of the bomb load be distributed inside the wings for short-range operation if a design load factor of 4 is to be maintained.

The selection charts of the main report are reproduced in two parts in the supplement, and the power loading of the charts have been extended to 30 pounds per horsepower.

USE OF SELECTION CHARTS

Performance selection charts extended to a power loading of 30 pounds per horsepower are presented in figure 13. Part I gives the speed, the rate of climb, and the take-off distance. Part II gives the maximum range with no bomb load and gives the disposable load which includes the gasoline, oil, and bombs.

Figures 14(a), 14(b), and 14(c) show plots of cargo capacity (which is made up of gasoline, oil, and bombs) plotted against the range for some bombers with a take-off distance of 3000 feet. These plots are made by graphical integration assuming that the cargo is carried one-half of the range. The end points for these curves are given in part II of the selection charts. It may be seen that these curves are nearly straight lines for low power loading and they are slightly concave for high power loading. If the shape of these curves for each power loading is observed, a good estimate of the curve of range versus cargo for any bomber on the selection chart may be drawn. By the use of these curves many interesting examples may be worked out in regard to cargo and economy for a given mission.

Cargo Capacity

By the use of the graphically integrated curves, such as those of figure 14, the curves (figs. 15(a), 15(b), 15(c), 16(a), 16(b), 16(c), 17(a), 17(b), and 17(c)) of constant cargo capacity for fixed ranges were drawn. These charts show that the bomb capacity is almost entirely dependent upon the power loading. Wing loading has almost no effect at a range of 1000 miles. There is an optimum wing loading for the 6000-mile range at high power loading and it comes in the range of practicable wing loadings.

It should be remembered that these airplanes are all calculated for a design load factor of 4 and when the gross weight is increased the structural weight is also increased to maintain this design load factor. This is mentioned to contrast it to the case of a given airplane being overlooked by adding cargo directly. Such a procedure gives an even more rapid increase with power loading than is shown on the figures.

Economy

By the use of figures, such as figure 14, the amount of bombs divided by the gasoline and oil may be computed. Figures 15(d), 15(e), 15(f), 16(d), 16(e), 16(f), 17(d), 17(e), and 17(f) show charts giving the ratio of bombs to gasoline and oil. This ratio attains importance when the supply problem becomes critical, as in the case of an air base obtaining its supplies by air transport. These charts are built on the assumption that the bombs and gasoline are interchangeable. The charts for 1000 miles range require approximately 15 percent of the cargo to be gasoline and oil load while those for 6000 miles range require at least 58 percent of the cargo to be fuel load. The determination of the most desirable degree of interchangability of gasoline and bombs is beyond the scope of this paper.

The importance of power loading is again shown by these charts and the effect of wing loading is more marked than on the cargo-capacity charts. In contrast to the cargo-capacity charts, there seems to be an optimum power loading in the neighborhood of 25 pounds per horsepower.

An interesting approximation to the economy for any range may be obtained if it is assumed that the curves of figure 14 are straight lines. From the geometry of figure 14 it may be seen that

$$\frac{\text{bomb load}}{\text{weight of gas and oil}} = \frac{R_{max} - R}{R} = \frac{R_{max}}{R} - 1$$

where R_{max} is the maximum range with no bombs and R is the range of operation (round trip).

An interesting corollary to this equation is obtained by multiplying both sides of the equation by R.

Then

$$\frac{\text{bomb load} \times \text{miles}}{\text{weight of gas and oil}} = R_{max} - R$$

Figure 18 gives the cross plots of the economy curves of figures 15, 16, and 17 for a take-off run of 3000 feet. However, these curves have been extended to include a power loading of 30. These curves bear a strong resemblance to curves of maximum range with no bomb load (fig. 2(a) of the original report). In each case a power loading of 30 has an economy less than at 25. The economy of the two-engine bomber falls somewhat below that of the four- and six-engine bombers. At low power loading the six-engine bombers are superior to the four-engine bombers and at high power loading the four-engine bomber is more economical.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 19, 1942.

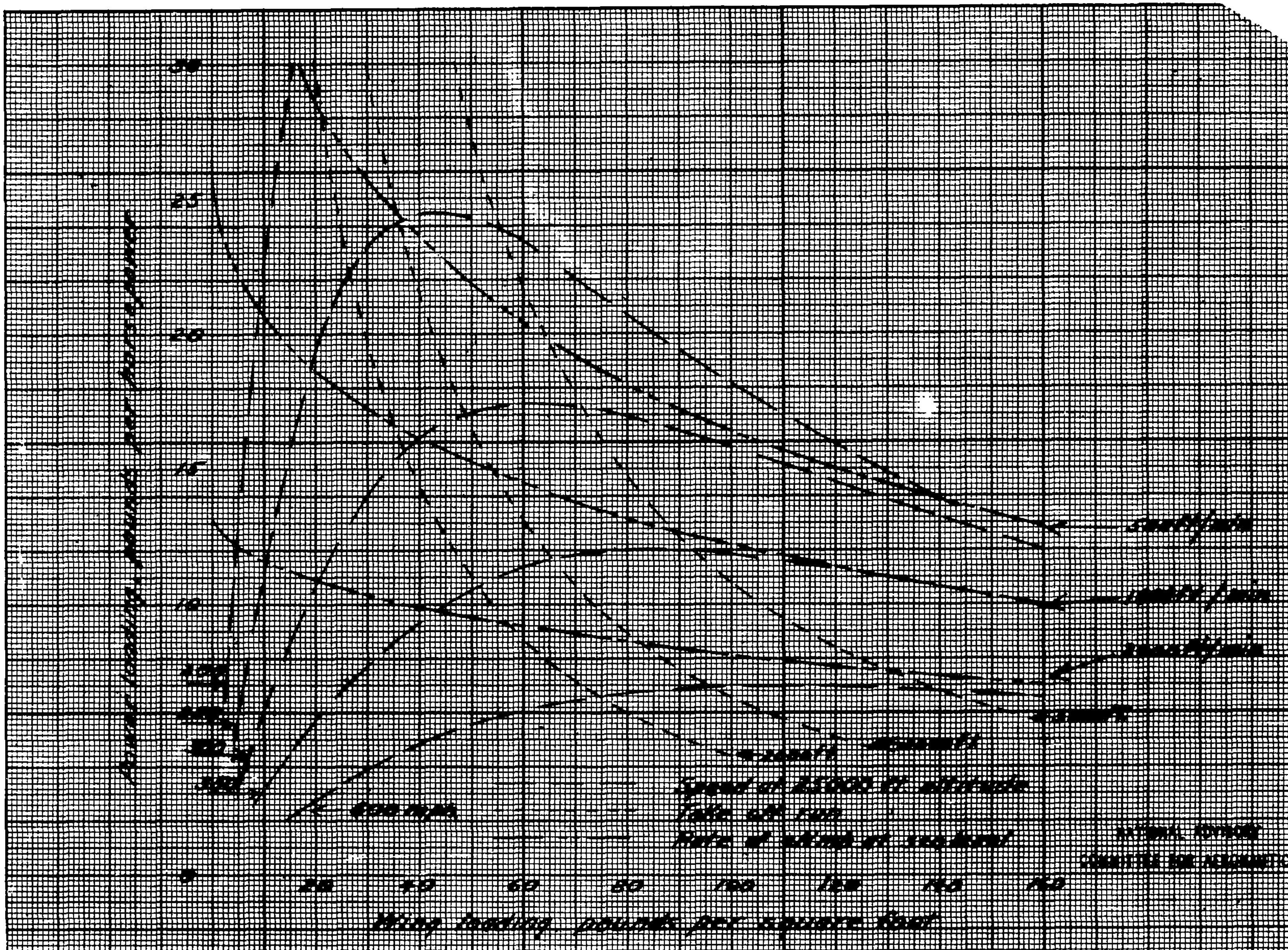


FIG. 13a—SELECTION CHART FOR BOMBERS POWERED BY TWO 2000-HP ENGINES PART ONE

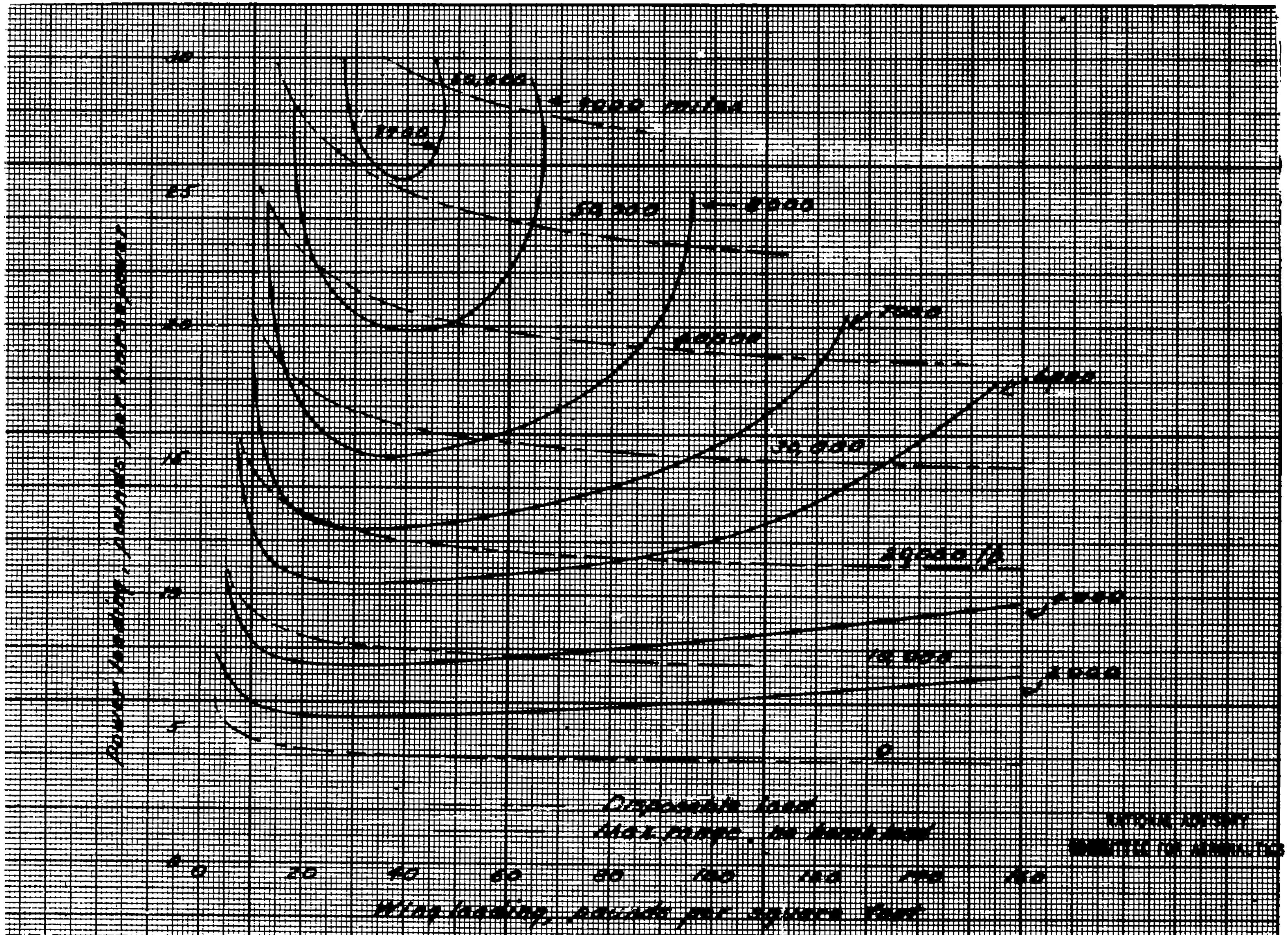


FIG. 11 A—SELECTION CHART FOR BOMBERS POWERED BY [illegible]

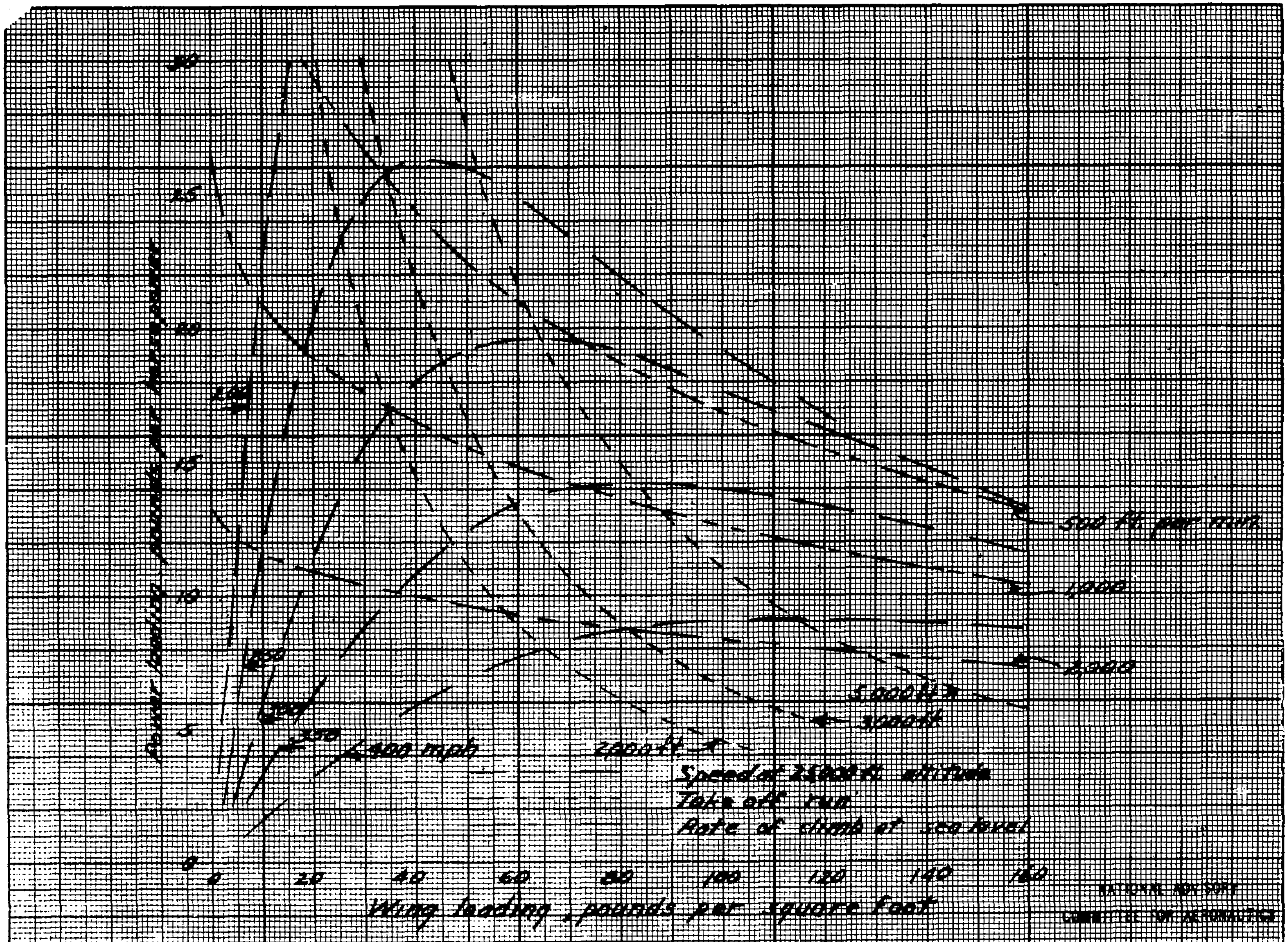


FIG. 13a - SELECTION CHART FOR BOMBERS POWERED BY FOUR-2000HP ENGINES PART ONE

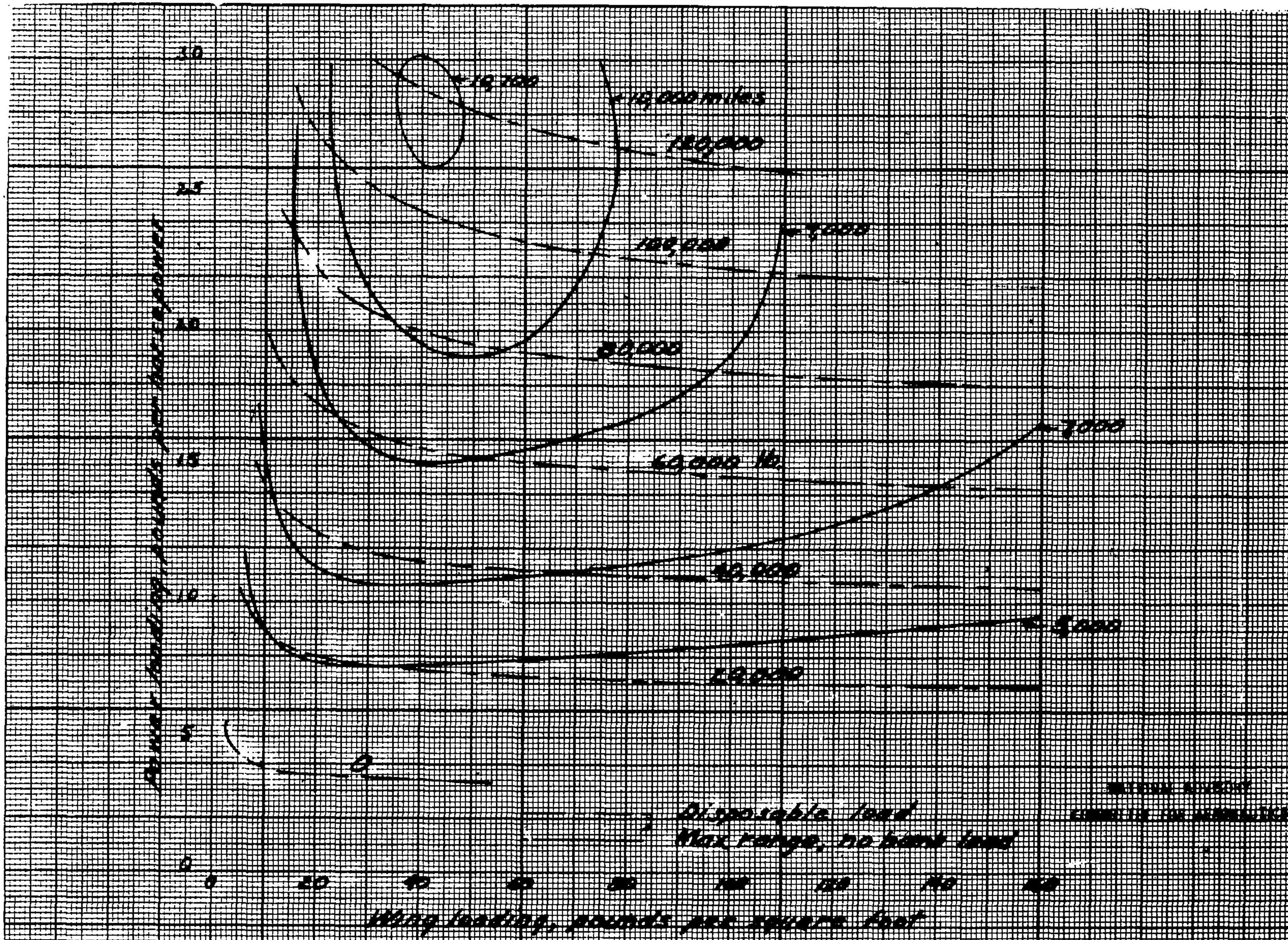


FIG 13d — SELECTION CHART FOR BOMBERS POWERED BY FOUR 2000 H.P. ENGINES

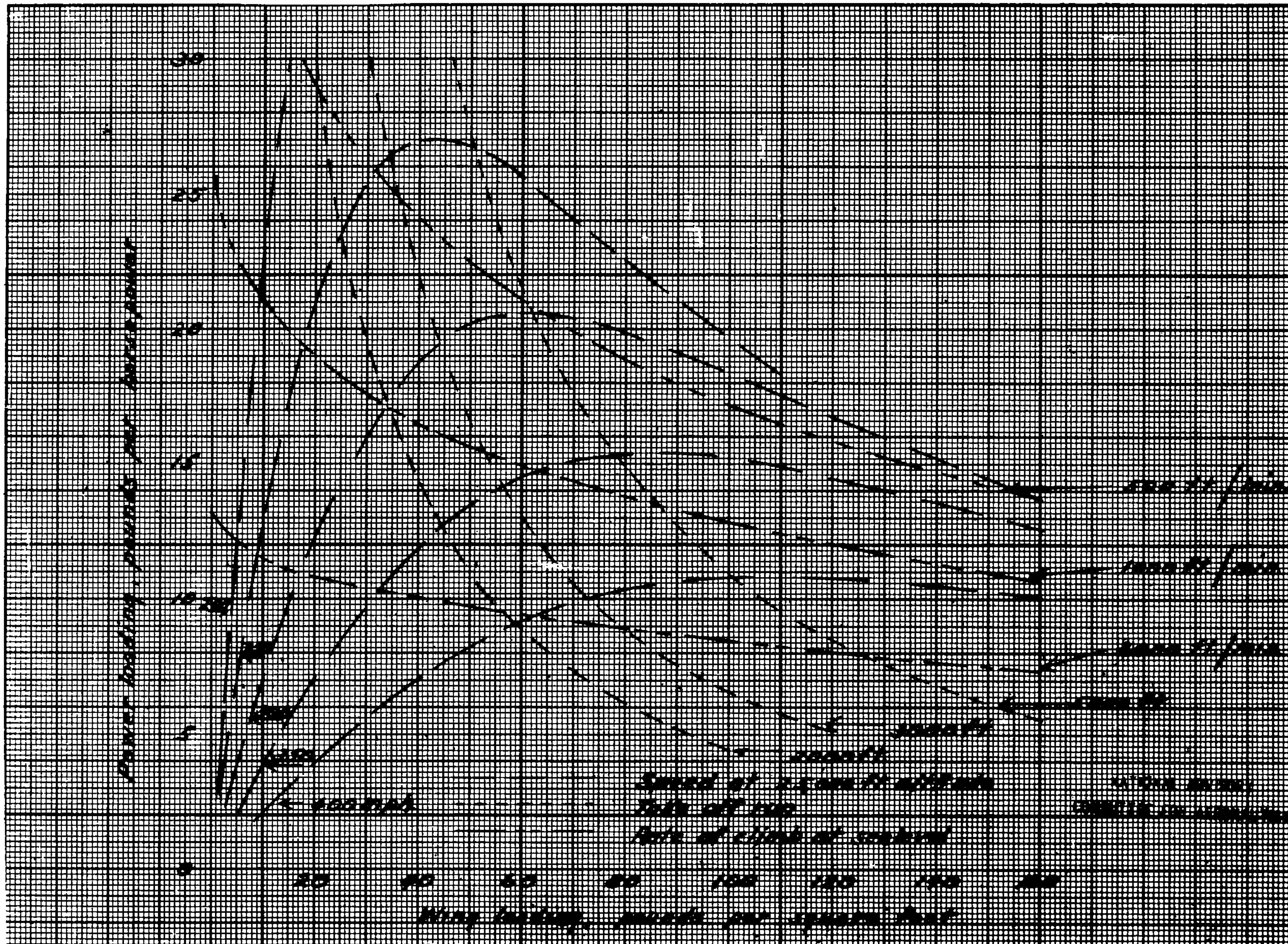
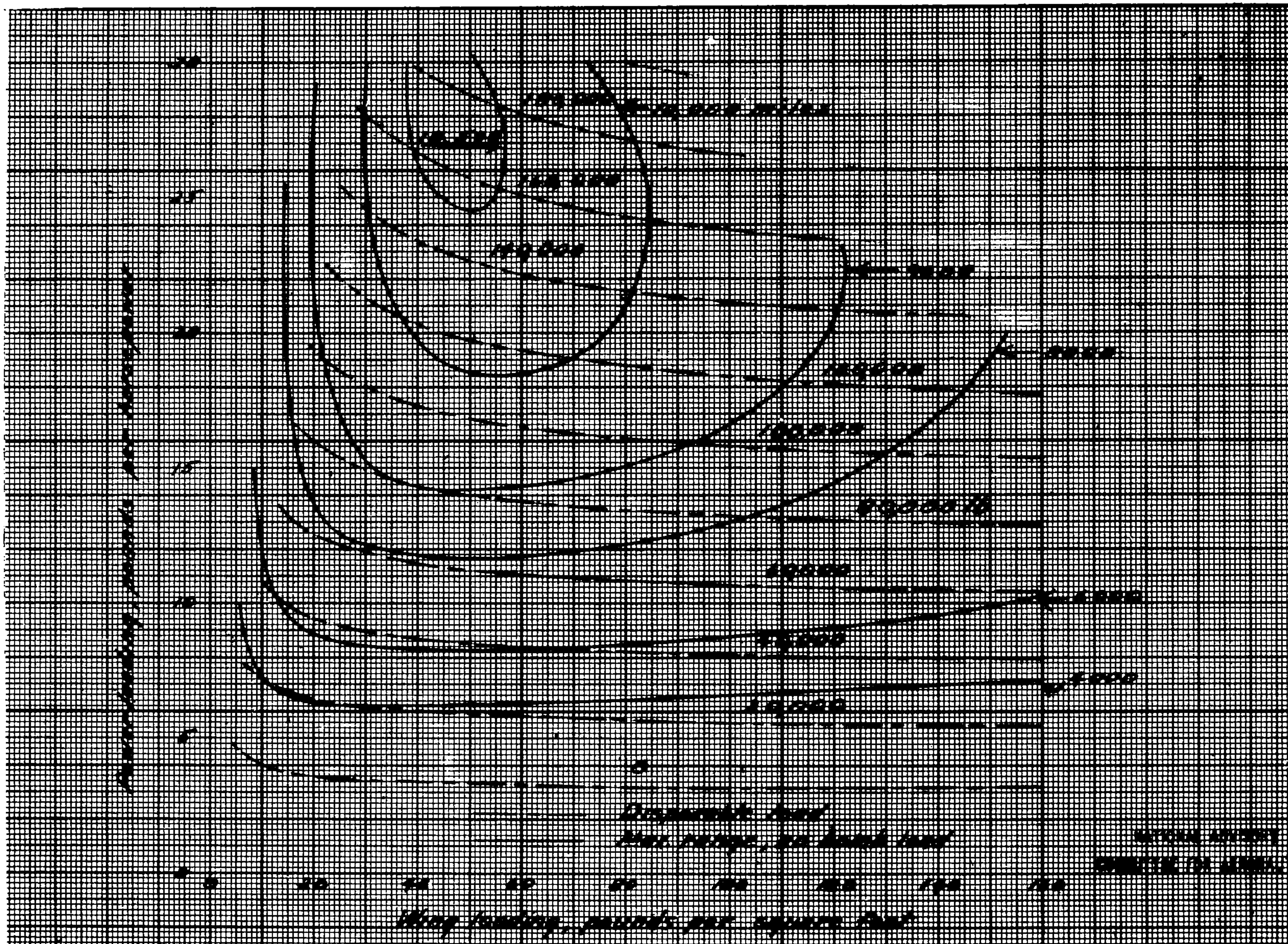


FIG. 13A – SELECTION CHART FOR BOMBERS [illegible]



—SELECTION CHART FOR BOMBERS POWERED BY [illegible] ENGINES

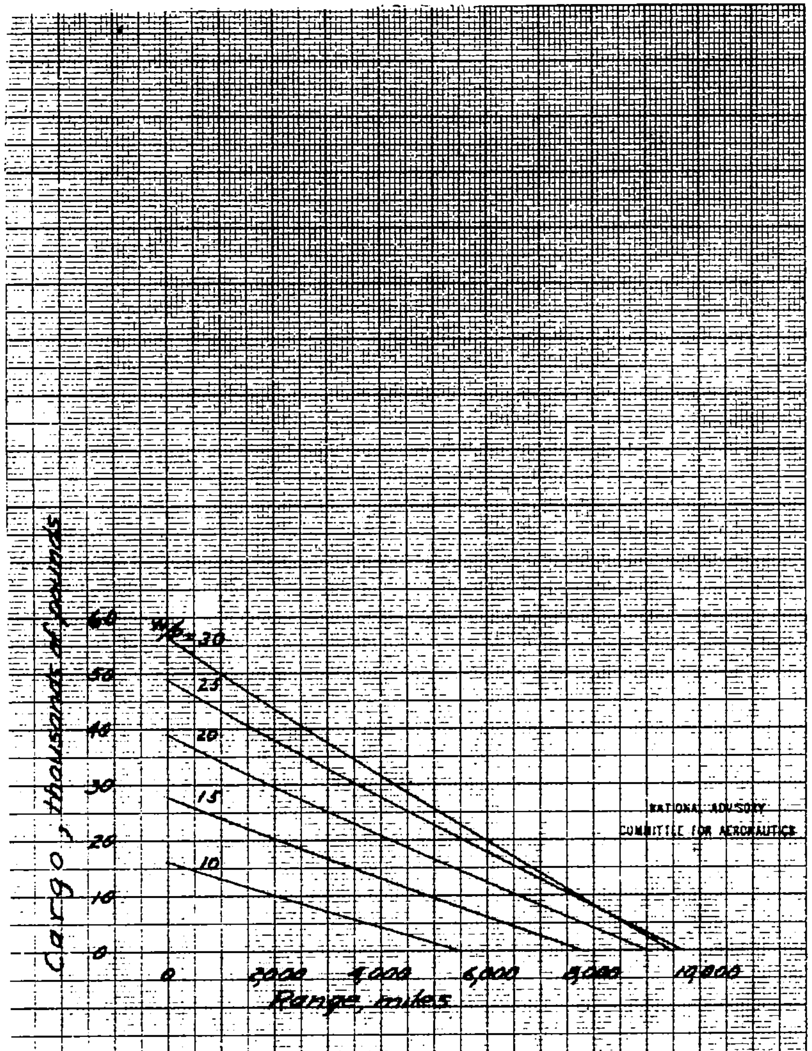


FIG. 14a-CARGO CAPACITY OF BOMBERS POWERED BY TWO 2,000-HP ENGINES 3,000 FT. TAKE OFF

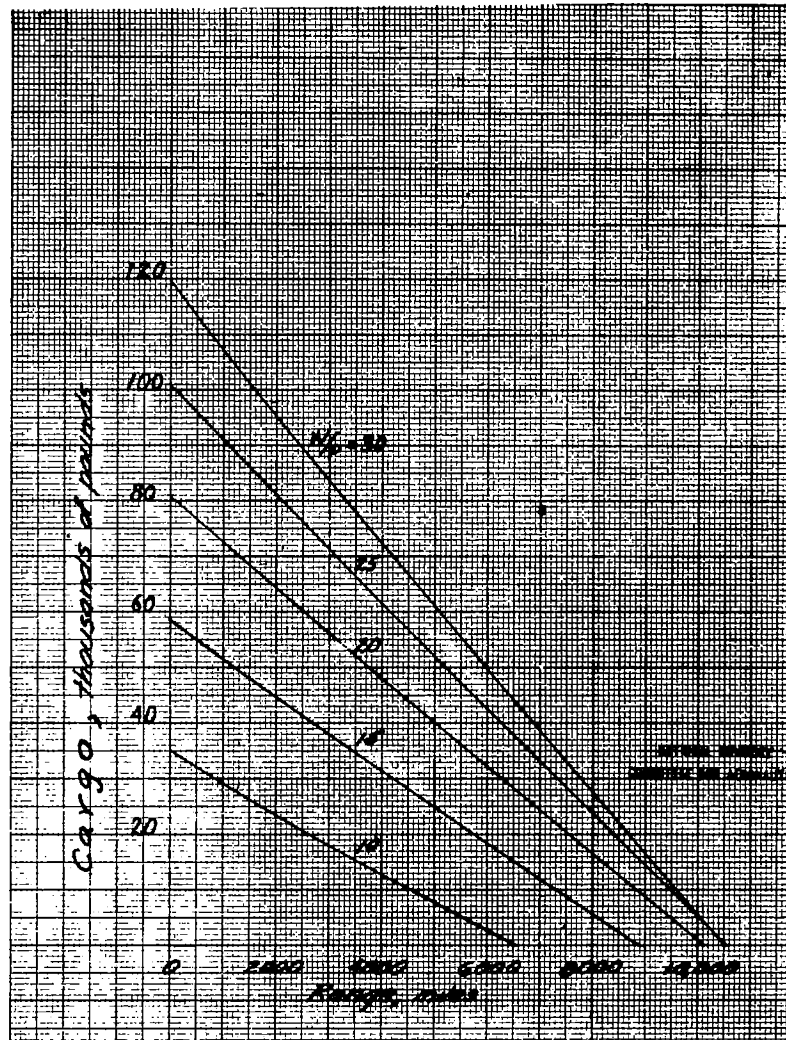


FIG. 14b-CARGO CAPACITY OF BOMBERS POWERED BY FOUR 2,000-HP ENGINES 3000 FOOT TAKE OFF

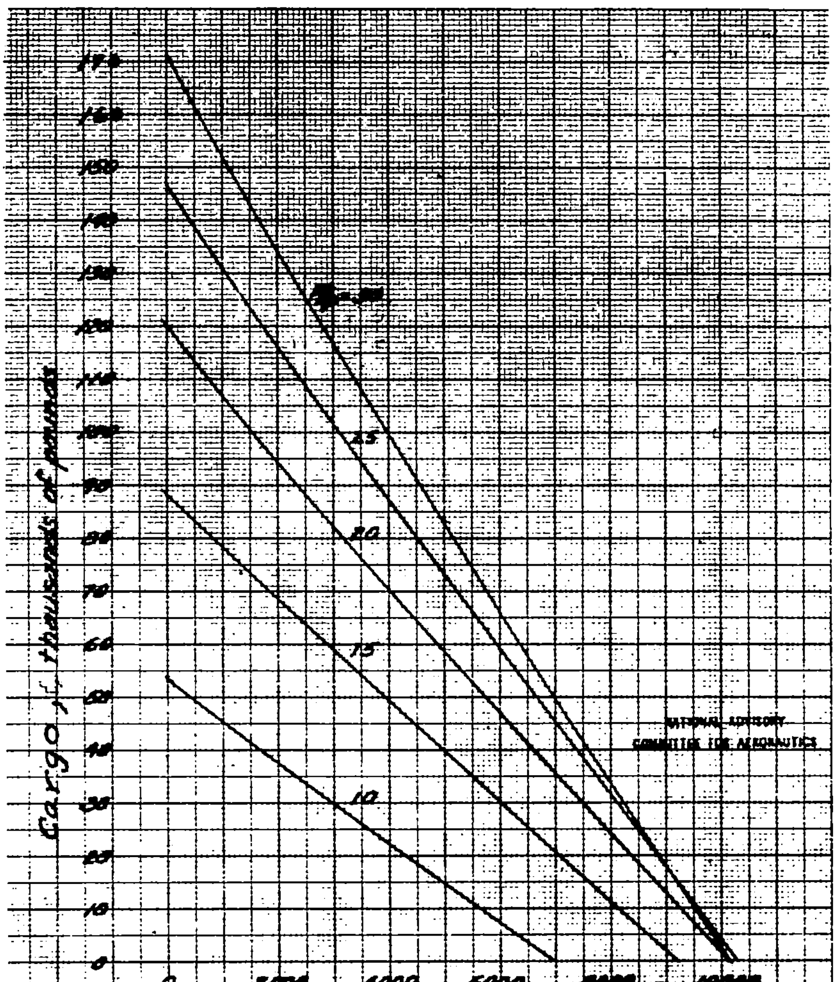


FIG.14C-CARGO CAPACITY OF BOMBERS POWERED BY SIX 2000-HP ENGINES 3000 FT. TAKE OFF

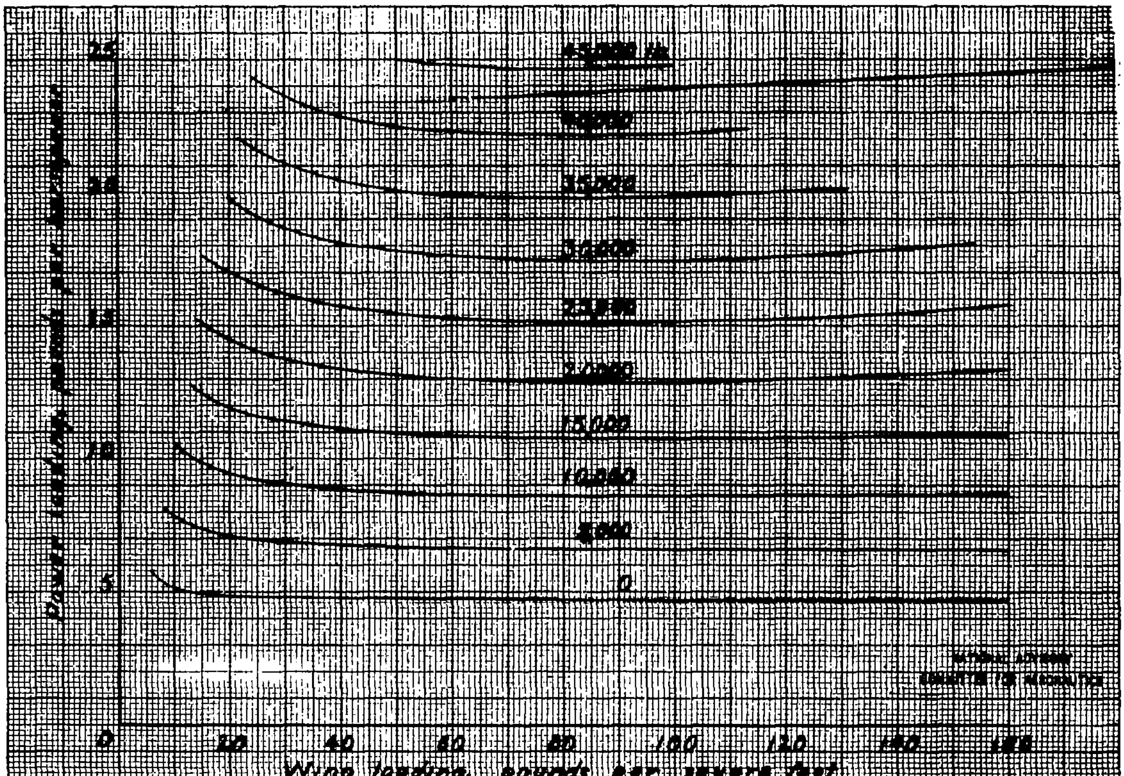


FIG. 15a - BOMB CAPACITY WITH 2-2000 HP ENGINES — 1000 MILE RANGE

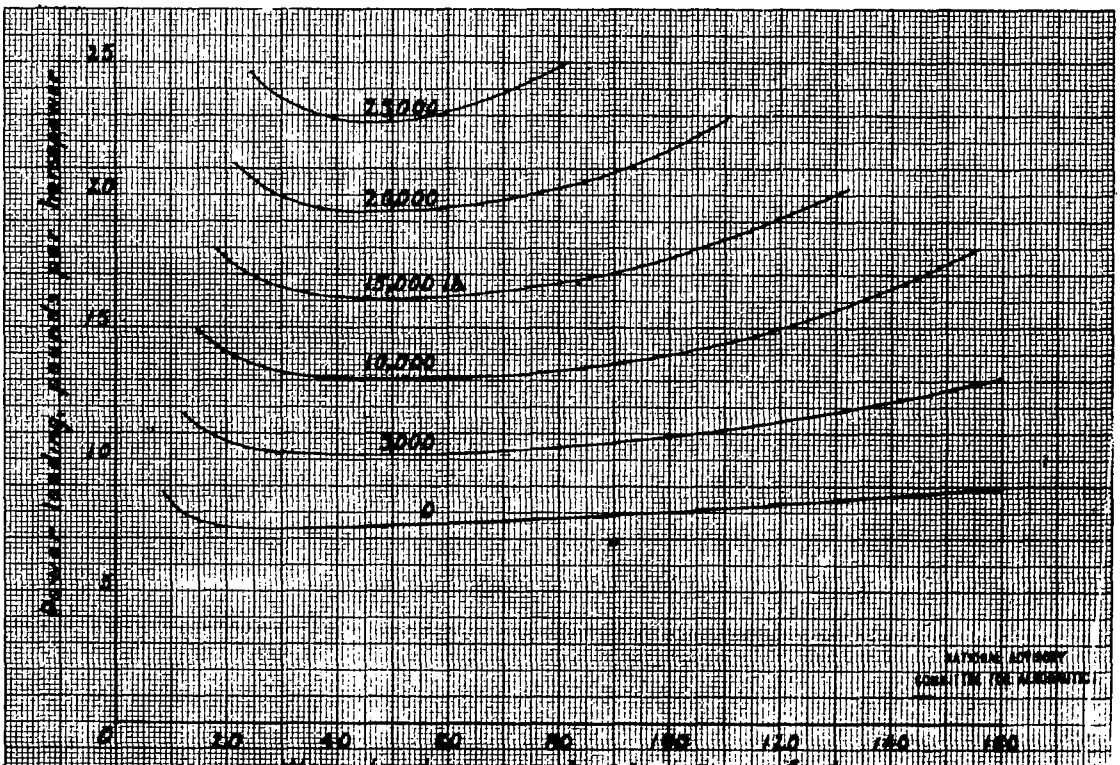


FIG. 15b - BOMB CAPACITY WITH 2-2000 HP ENGINES — 4000 MILE RANGE

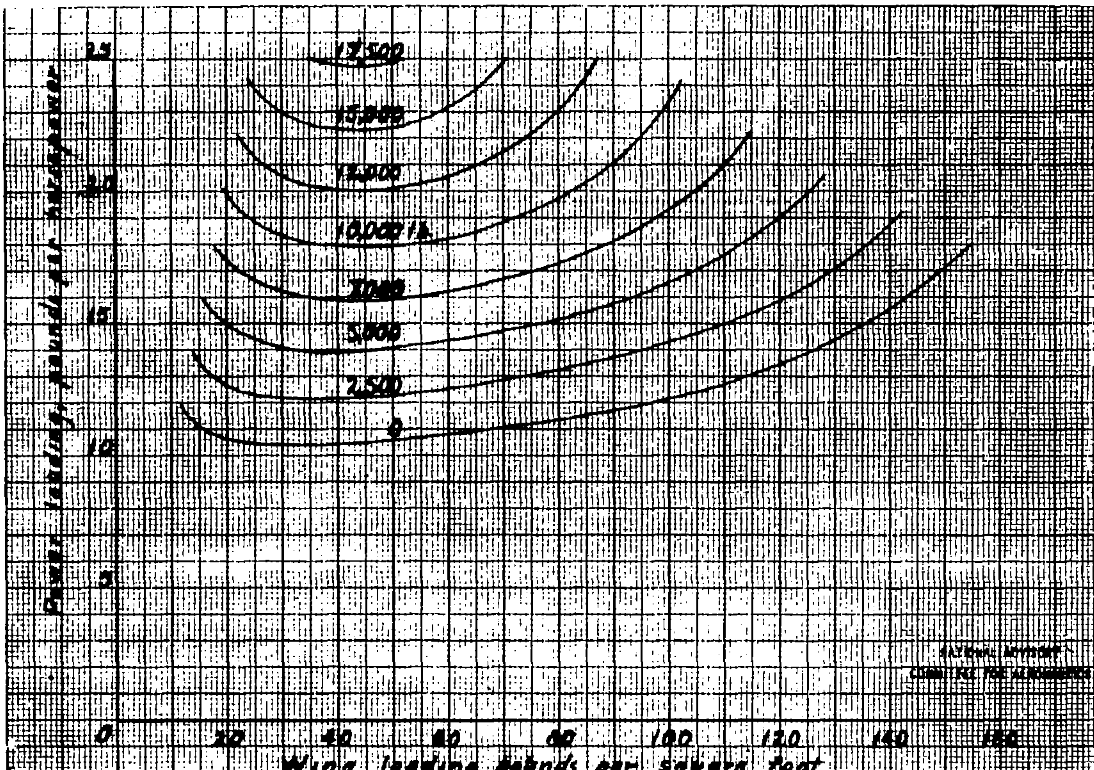


FIG. 15.— BOMB CAPACITY WITH 2-2,000 HP ENGINES— 6,000 MILES RANGE

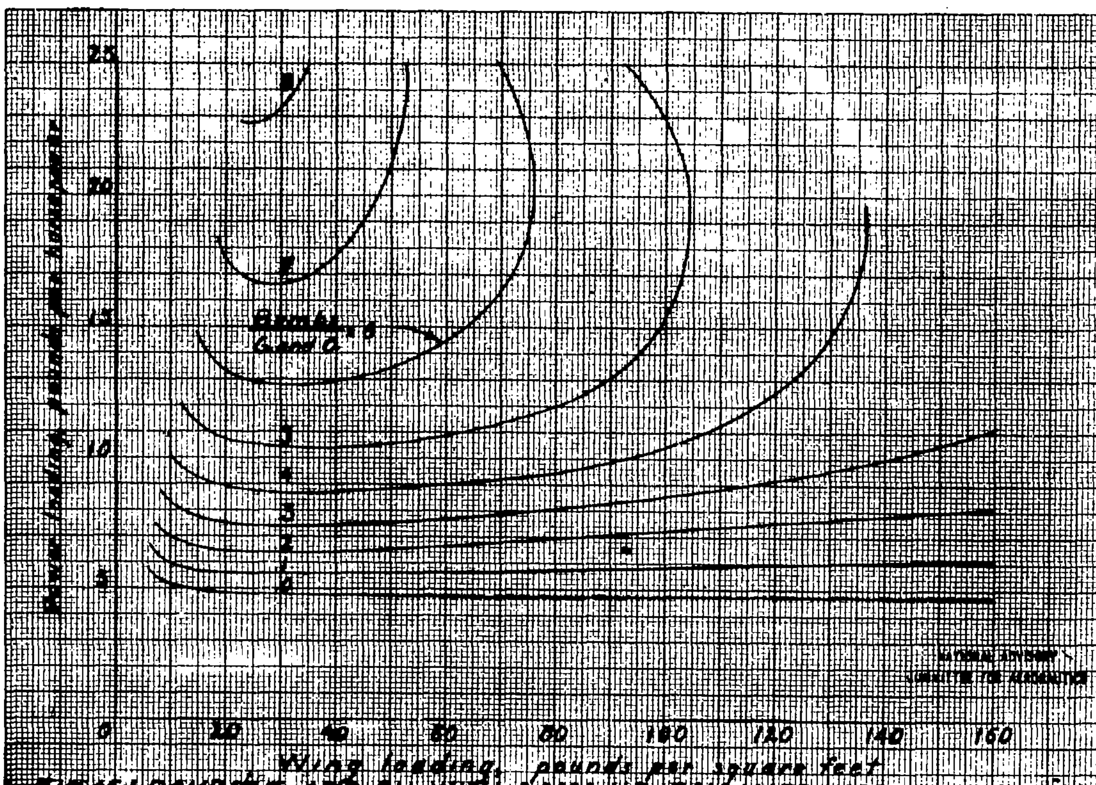


FIG. 15a.— BOMBS AND OIL WITH 2-2000 HP ENGINES 1,000 MILE RANGE

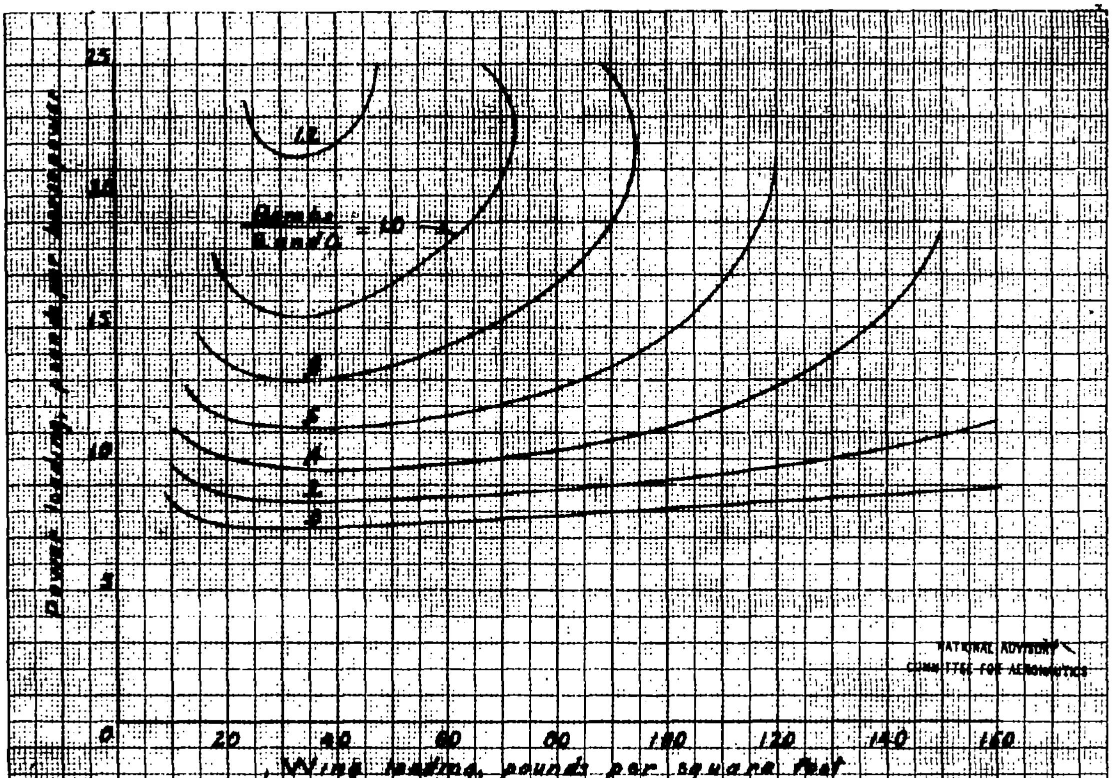


FIG. 15e–BOMBS/GAS AND OIL WITH 2-2,000 HP ENGINES—4,000 MILE RANGE

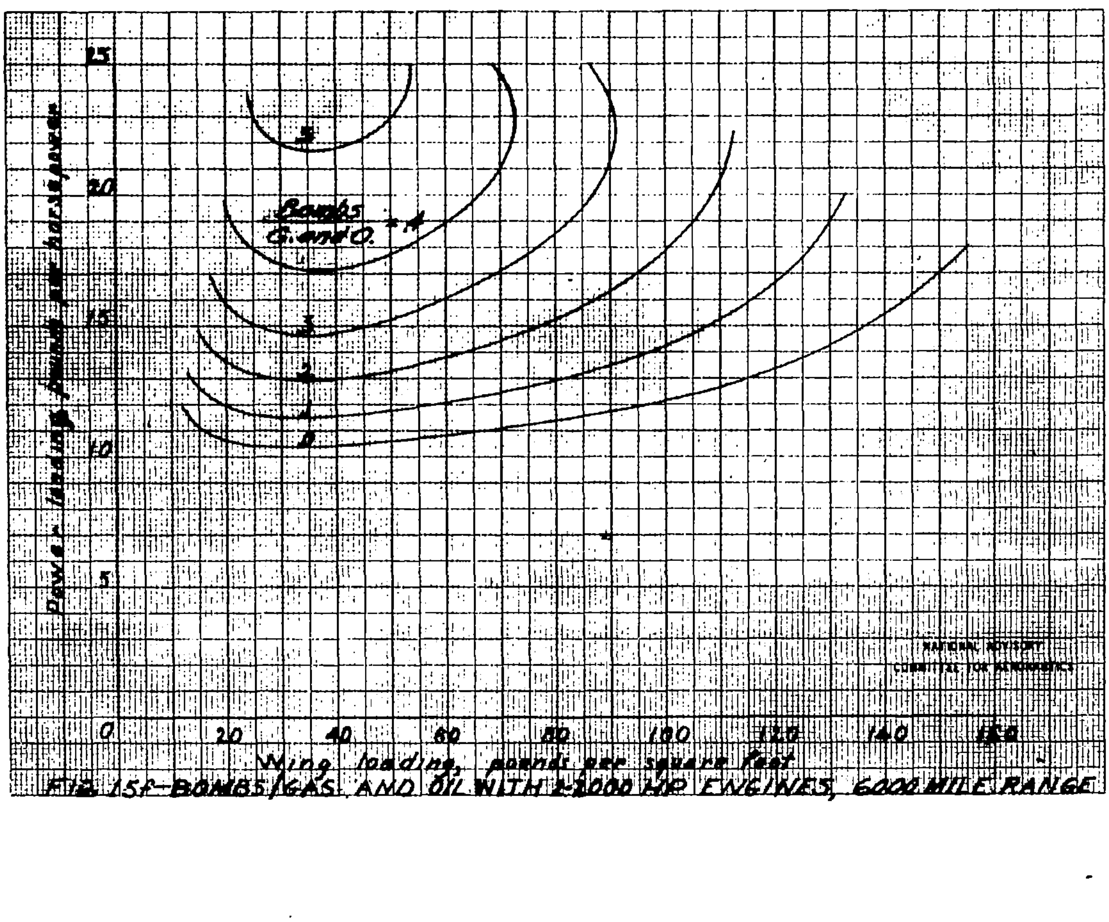


FIG. 15f–BOMBS/GAS AND OIL WITH 2-2000 HP ENGINES, 6000 MILE RANGE

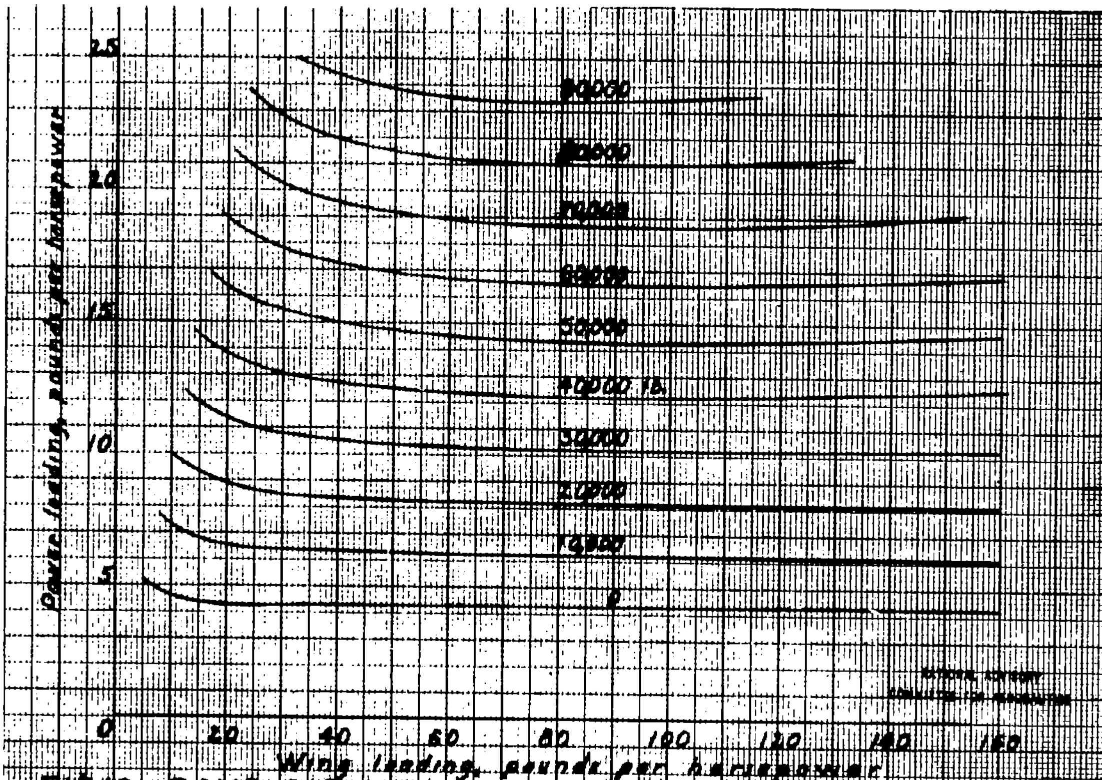


FIG. 16a—BOMB CAPACITY WITH 4-2,000 HP ENGINES—1,000 MILE RANGE

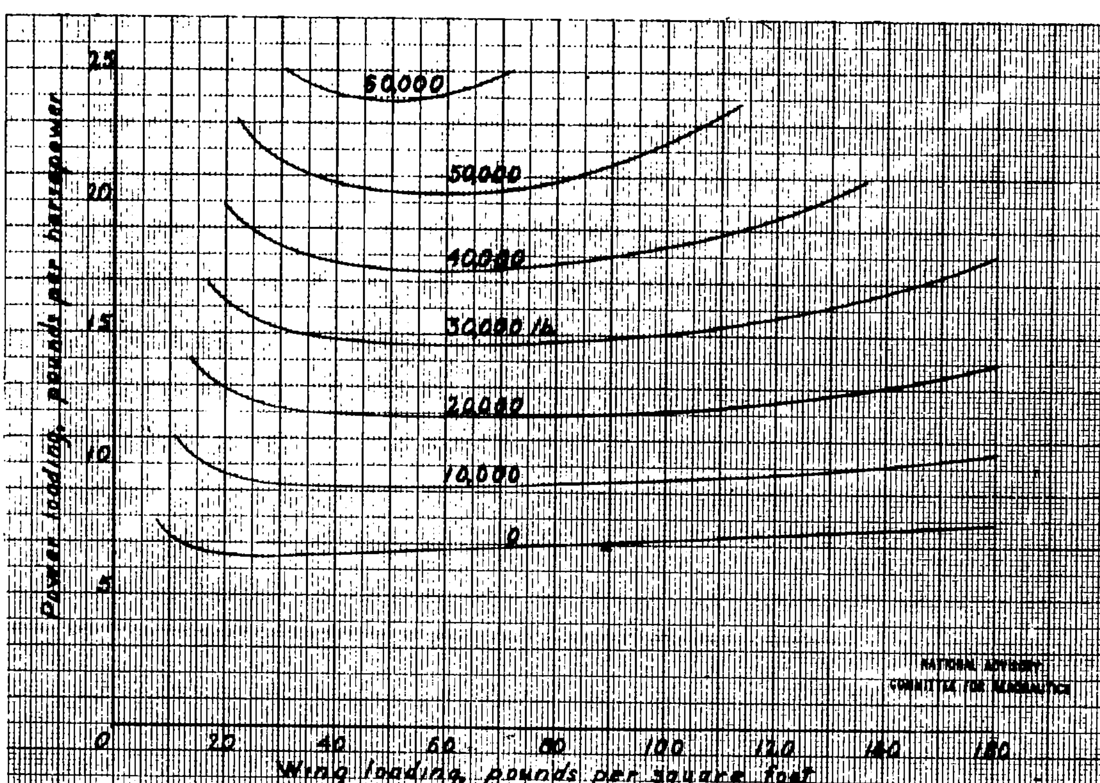


FIG. 16b—BOMB CAPACITY WITH 4-2000 HP ENGINES—4,000 MILE RANGE

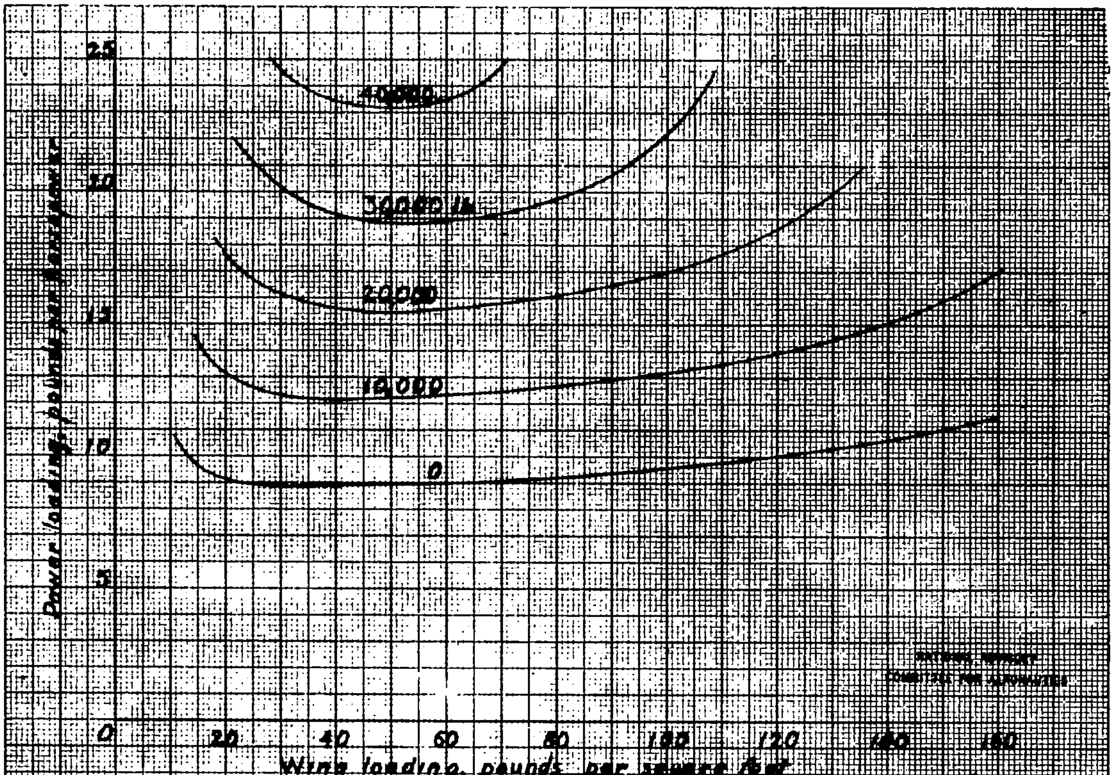


FIG. 16c—BOMB CAPACITY WITH 4-2,000 HP ENGINES—5000 MILE RANGE

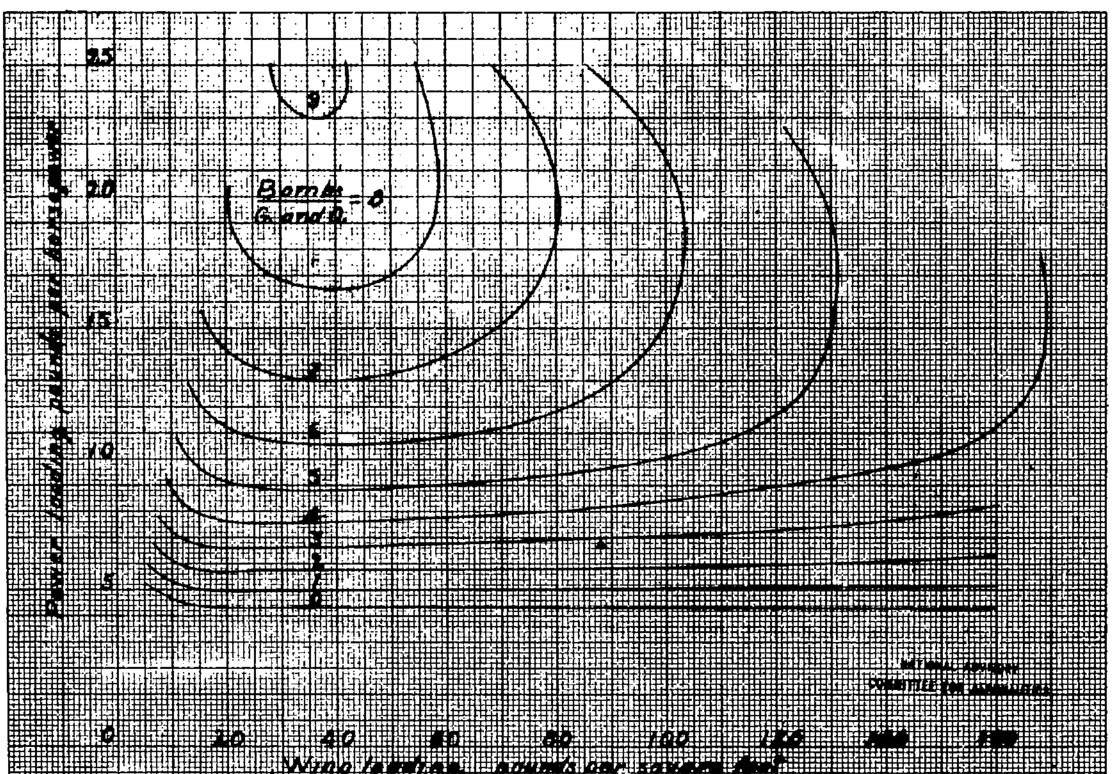


FIG. 16d—BOMB/GAS AND OIL WITH 4-2,000 HP ENGINES—[illegible] MILE RANGE

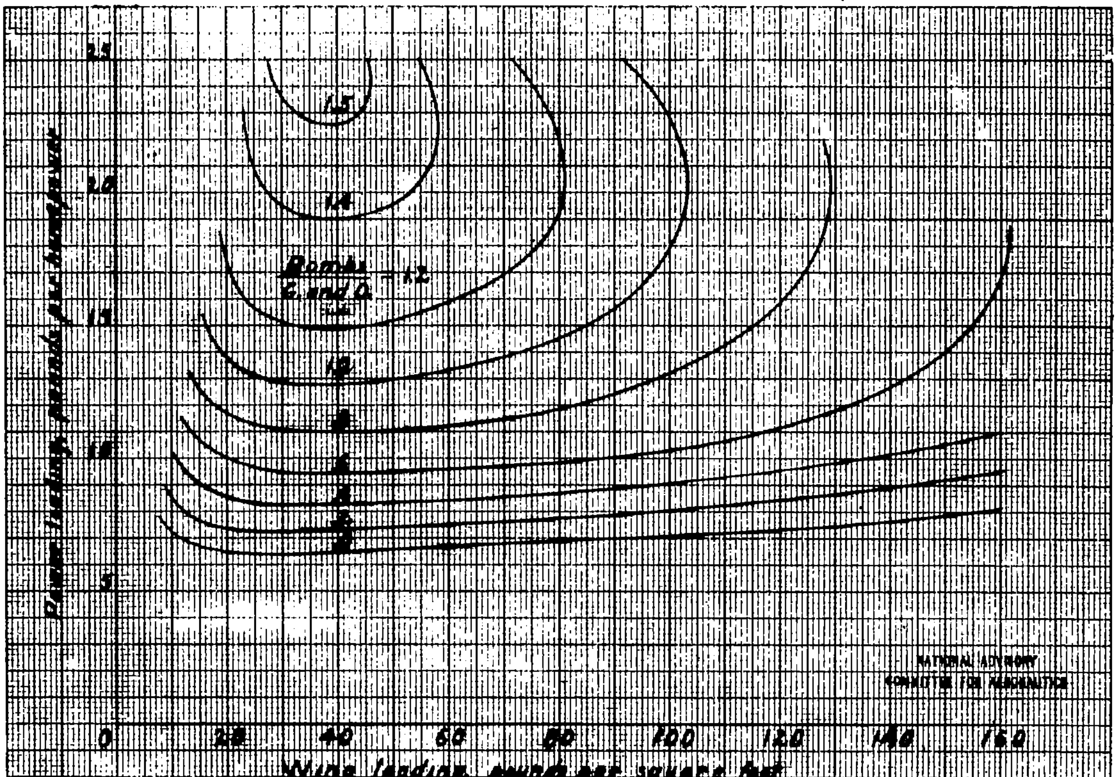


FIG. 16a — BOMBS/GAS AND OIL WITH [illegible] HP ENGINES — 4000 MILE RANGE

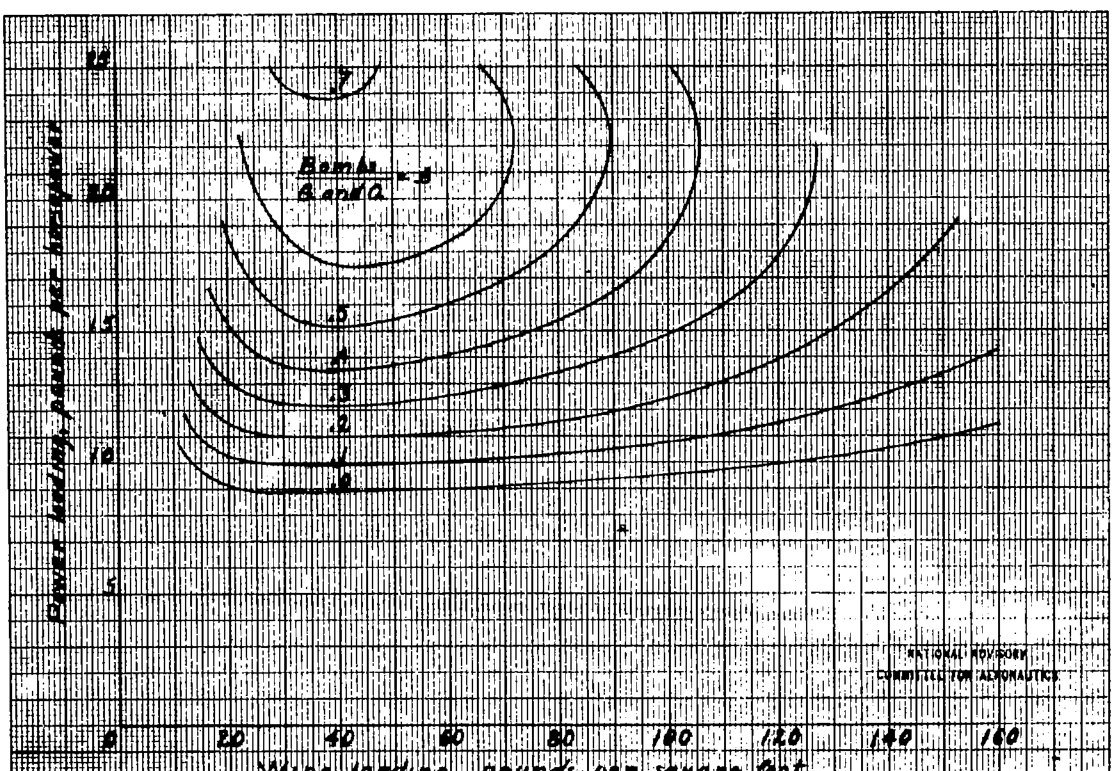


FIG. 16b — BOMBS/GAS AND OIL WITH 4-2,000 HP ENGINES — 5,000 MILE RANGE

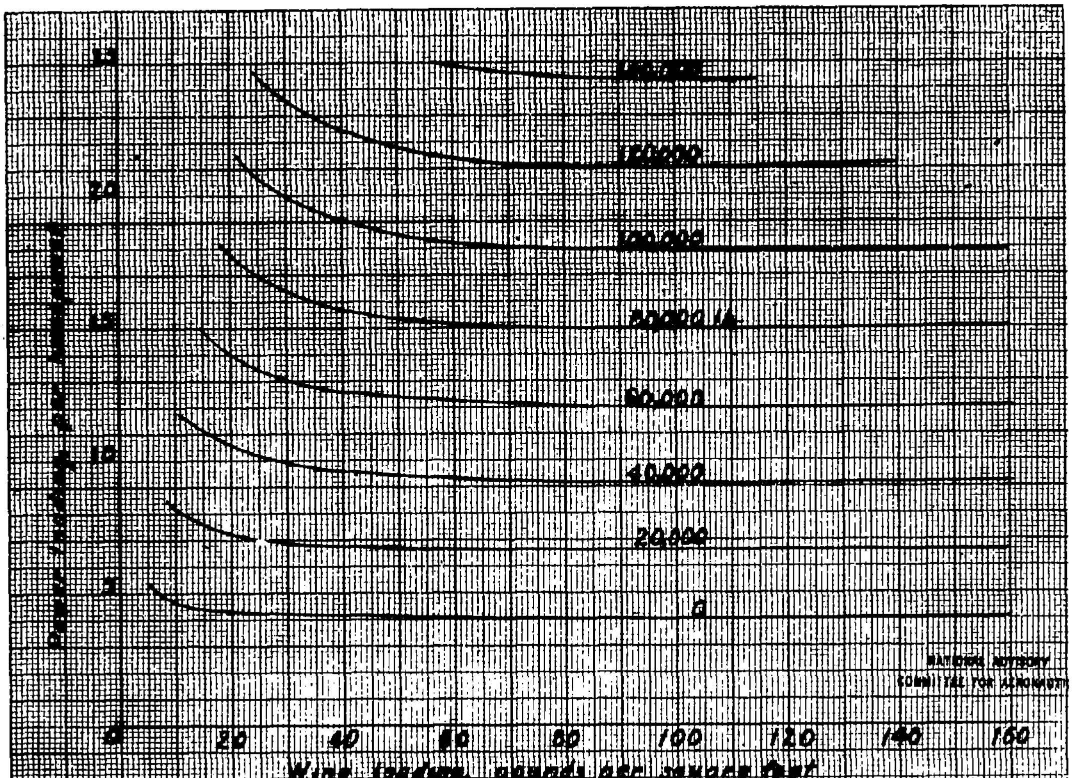


FIG. 17a—BOMB CAPACITY—6-2,000 HP. ENGINES—1000 MILE RANGE

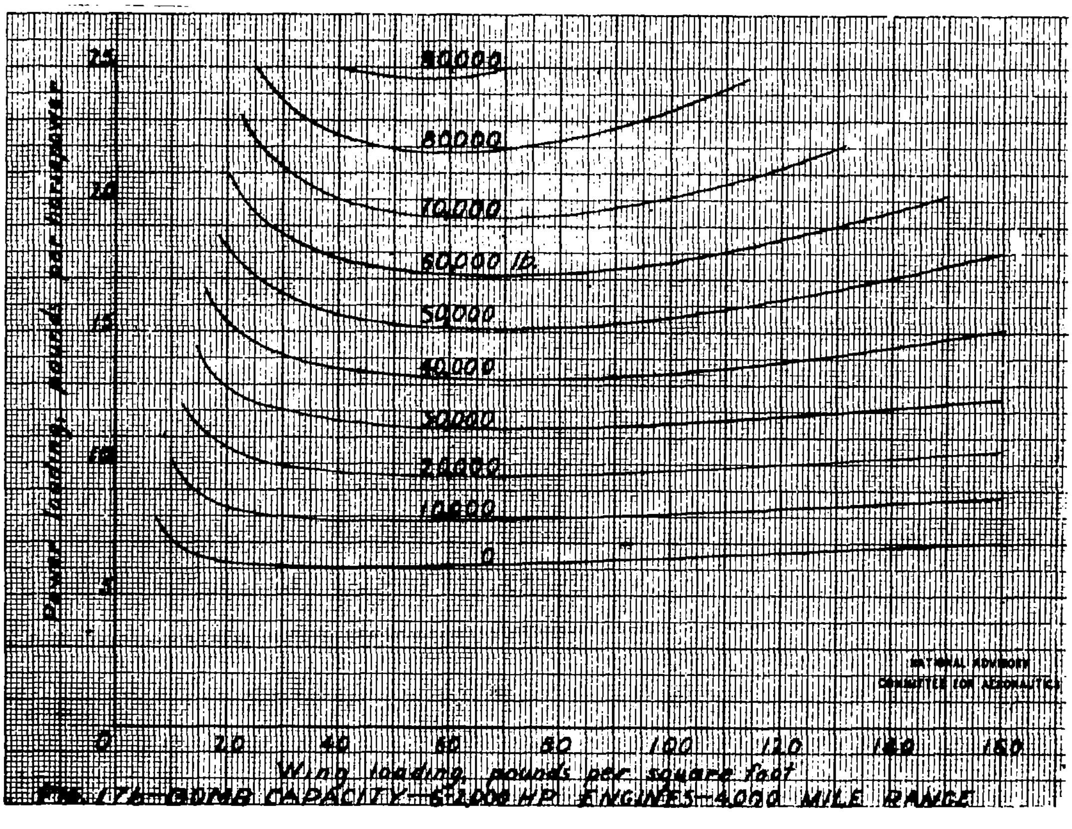


FIG. 17b—BOMB CAPACITY—6-2,000 HP. ENGINES—4000 MILE RANGE

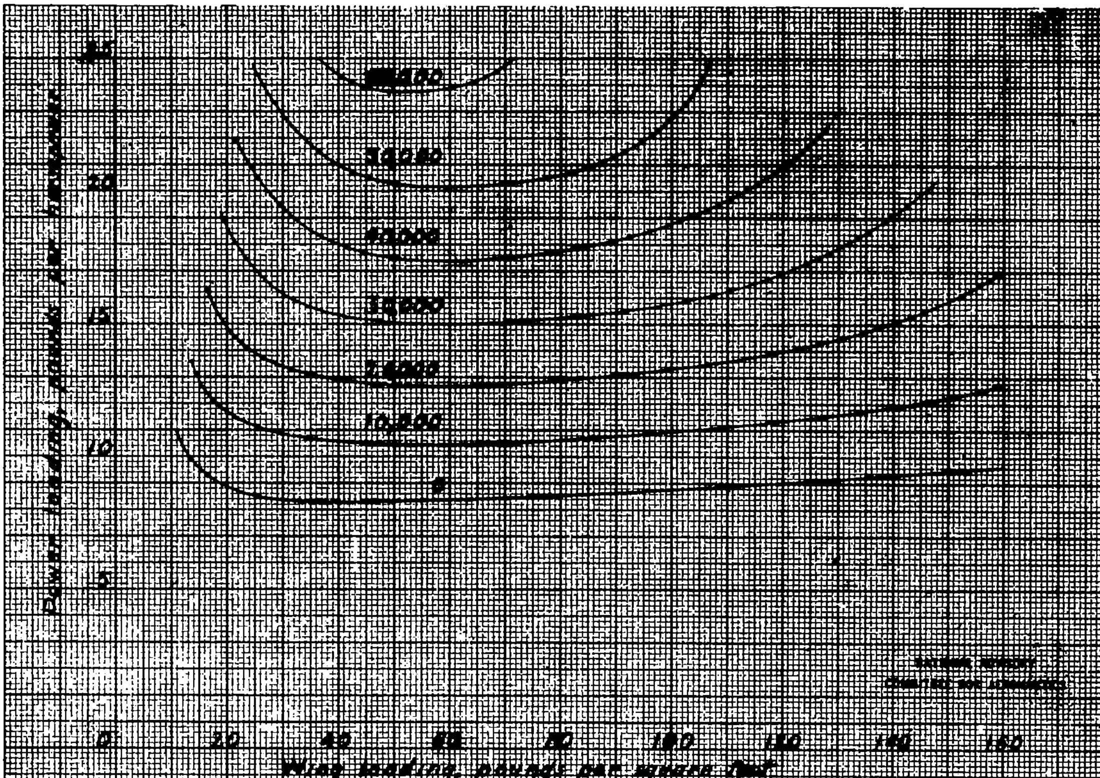


FIG. 17c - BOMB CAPACITY WITH 6-2000 HP ENGINES - 6000 MILE RANGE

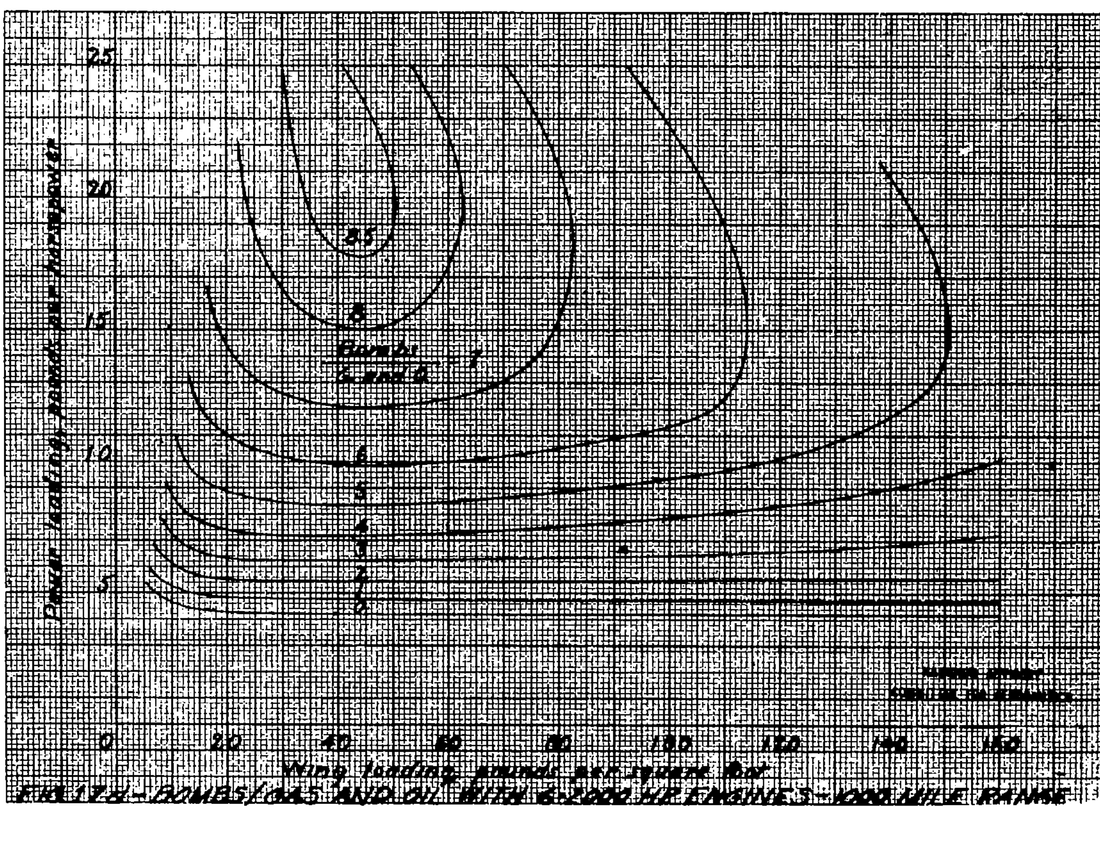


FIG. 17d - BOMBS/GAS AND OIL WITH 6-2000 HP ENGINES - 1000 MILE RANGE

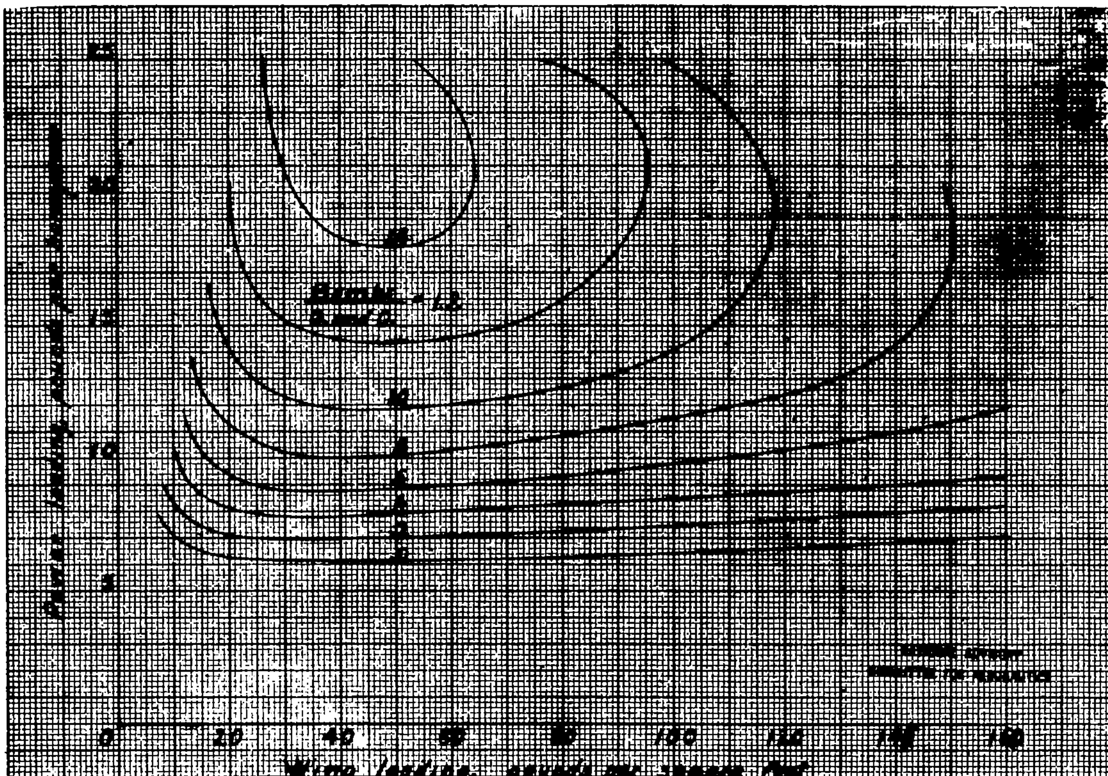


FIG. 17b - BOMBS/GAS AND OIL WITH [illegible] HP ENGINES — [illegible] MILE RANGE

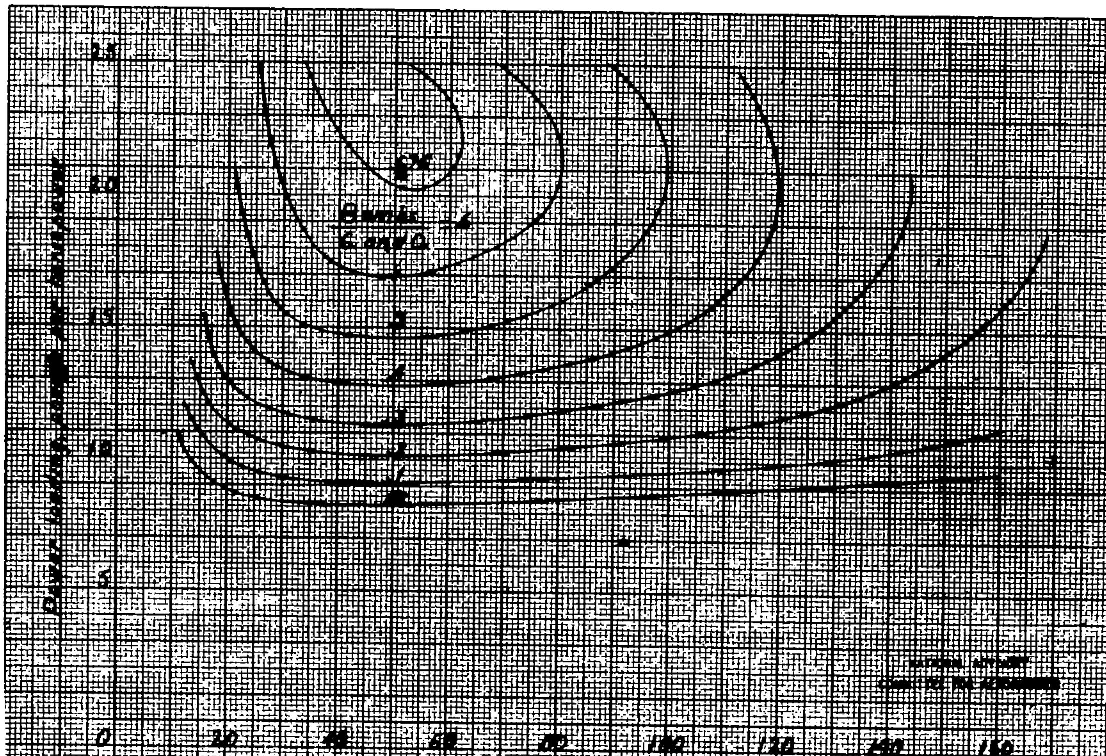


FIG. 17c - BOMBS/GAS AND OIL WITH 6 - 2000 HP ENGINES - 6000 MILE RANGE

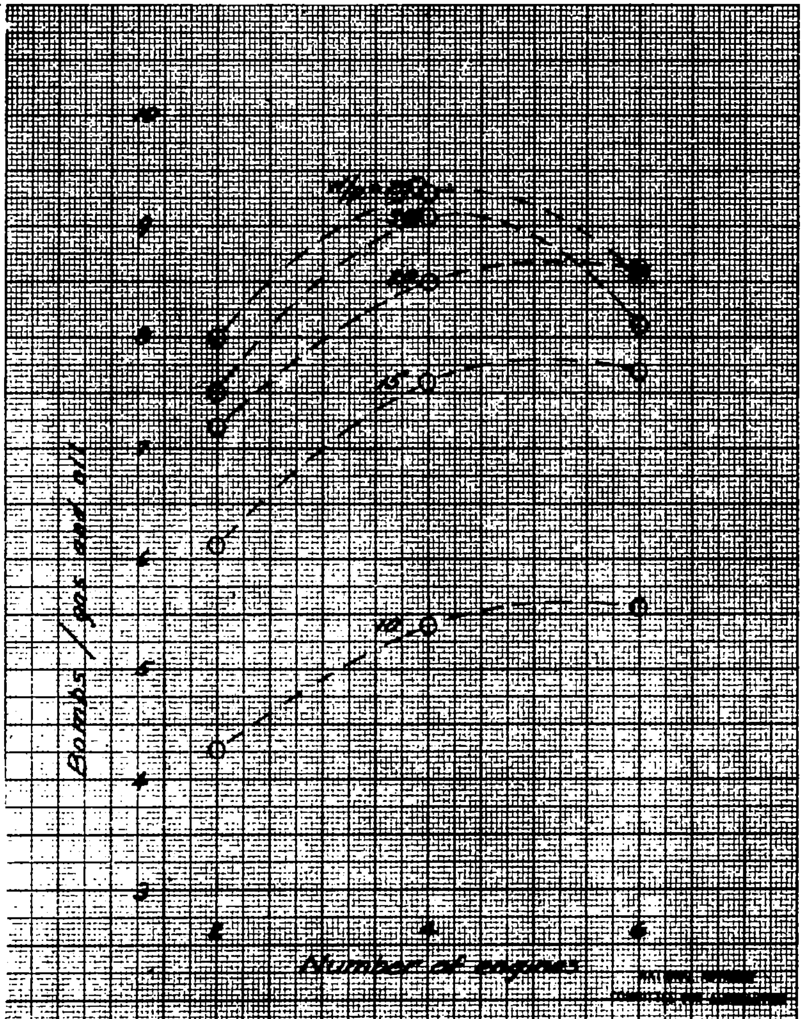


FIG 18a – EFFECT OF NUMBER OF ENGINES ON ECONOMY FOR A 1000 MILE RANGE 3000 FOOT TAKE OFF

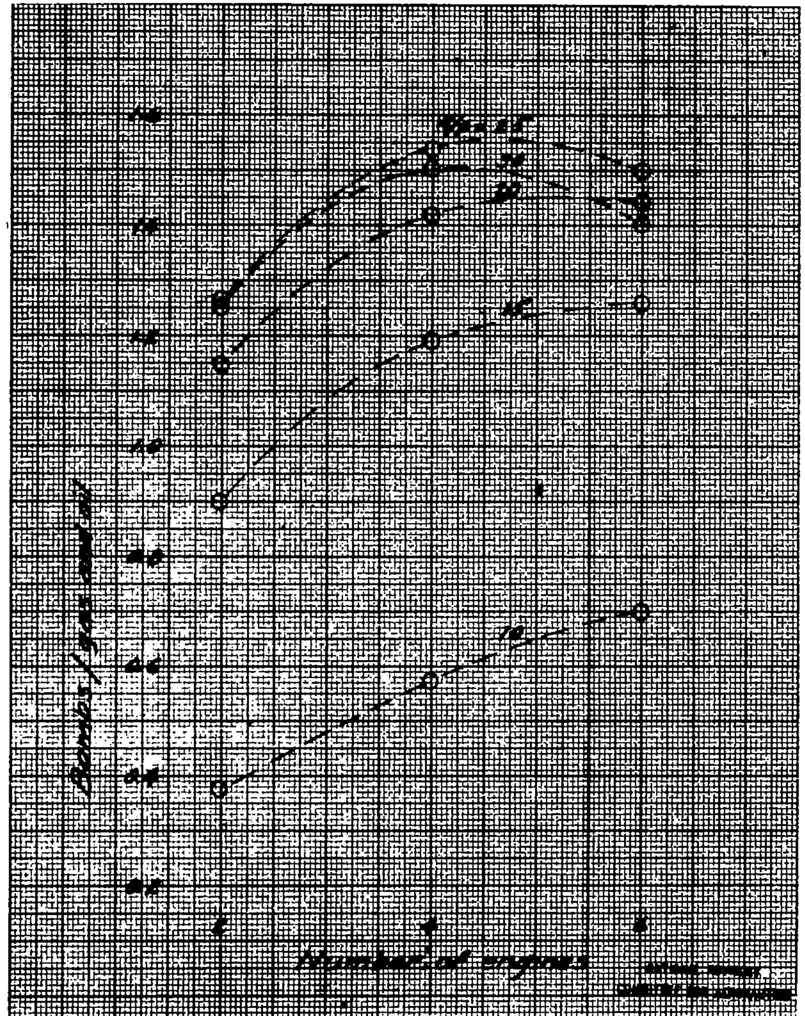


FIG 18b – EFFECT OF NUMBER OF ENGINES ON ECONOMY FOR A [illegible] MILE RANGE 3,000 FOOT TAKE OFF

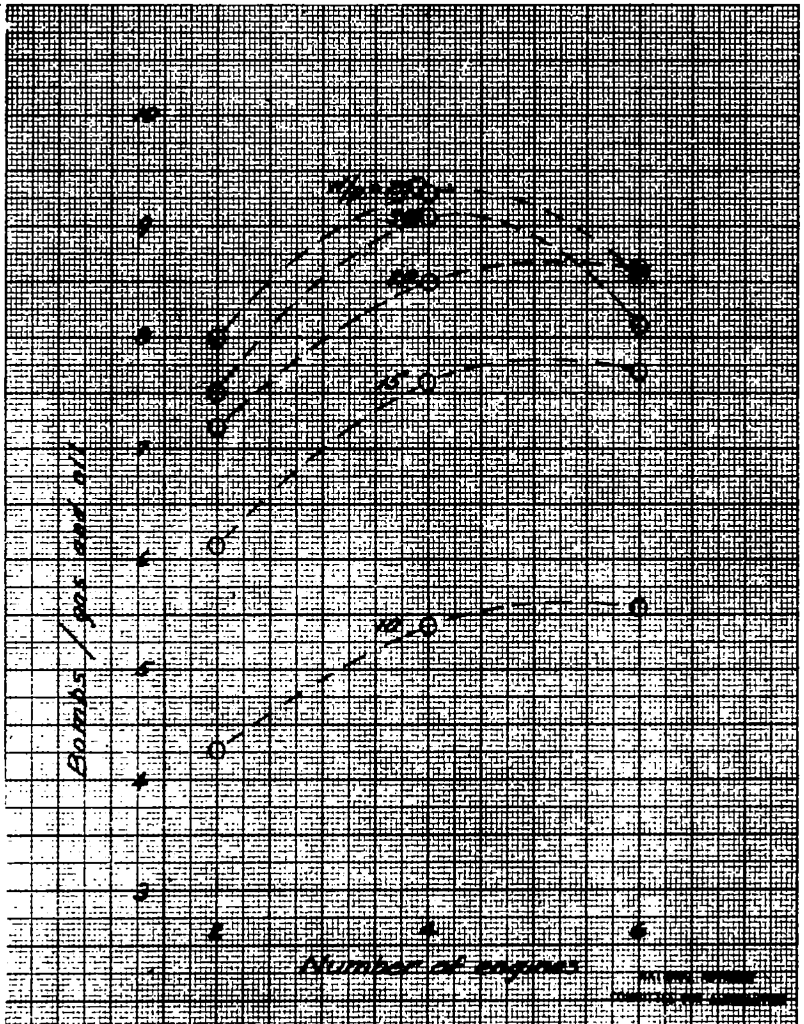


FIG 18a — EFFECT OF NUMBER OF ENGINES ON ECONOMY FOR A 1000 MILE RANGE 2000 FOOT TAKE OFF

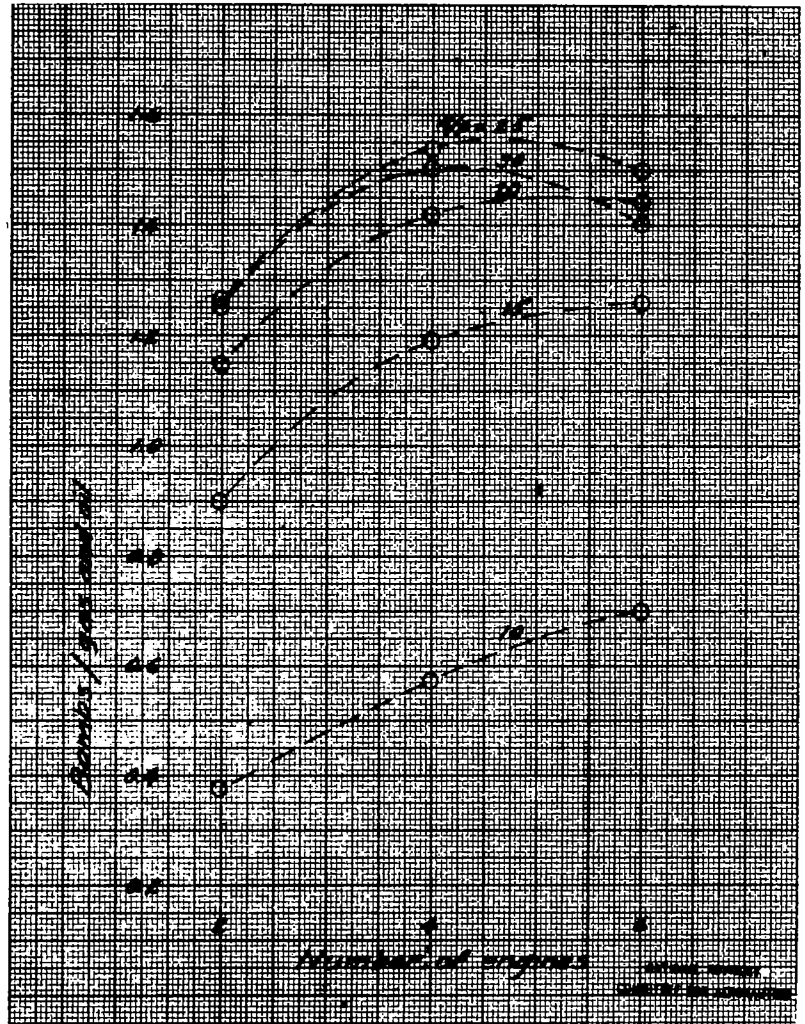
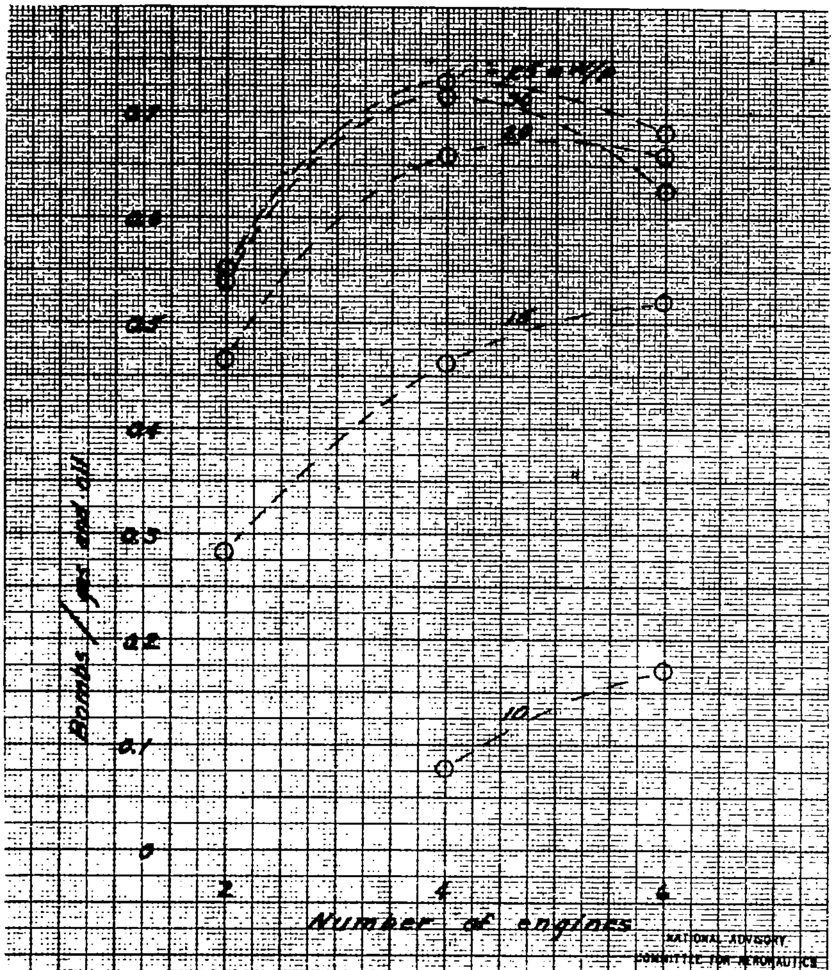


FIG 18b — EFFECT OF NUMBER OF ENGINES ON ECONOMY FOR A 4000 MILE RANGE 3000 FOOT TAKE OFF



NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

FIG 18a – EFFECT OF NUMBER OF ENGINES ON ECONOMY FOR A 6000 MILE RANGE 3000 FOOT TAKE OFF

TSDIN FORM 68 (13 MAR 47)

Brevoort, M. J.
Stickle, G. W.
Hill, Paul R.

AUTHOR(S)

R-10-11-10

DIVISION: Airplane Design and Description (10)

SECTION: Military Airplane (11)

CROSS REFERENCES: Airplanes, Pay loads (08478.2) Airplanes, Bomber - Load distribution (08514)

ATI- 10928

ORIG. AGENCY NUMBER

MR-L-658

REVISION

AMER. TITLE: Generalized selection charts for bombers powered by one, two, four, and six 2000-horsepower engines - I - Capacity and economy

FORG'N. TITLE:

ORIGINATING AGENCY: National Advisory Committee for Aeronautics, Washington, D. C.

TRANSLATION:

COUNTRY	LANGUAGE	FORG'N.CLASS	U. S.CLASS.	DATE	PAGES	ILLUS.	FEATURES
U.S.	Eng.		Unclass.	Sep'42	23	19	graphs

ABSTRACT

Curves show data on amount of cargo which can be carried at various ranges and pounds of cargo which can be carried per pound of fuel. Analysis was conducted for design load factor of 4. Charts show that bomb capacity is almost entirely dependent upon power loading and that wing loading has no effect at 1000 mile range. For 1000-mile range, 15% of cargo should be fuel; for 6000 miles 58% should be fuel. Optimum power loading is approximately 25 lb/hp.

NOTE: REQUESTS FOR COPIES MUST BE ADDRESSED TO N.A.C.A., WASHINGTON, D. C.

TSDIC FORM 69 (13 MAR 47)

Brevoort, M. J.
Stickle, G. W.
Hill, Paul R.

AUTHOR(S)

R-10-11-10

DIVISION: Airplane Design and Description (10)
SECTION: Military Airplane (11)
CROSS REFERENCES: Airplanes, Pay loads (08478.2) Airplanes, Bomber - Load distribution (08514)

ATI- 10928
ORIG. AGENCY NUMBER
MR-L-658
REVISION

AMER. TITLE: Generalized selection charts for bombers powered by one, two, four, and six 2000-horsepower engines - I - Capacity and economy
FORG'N. TITLE:

ORIGINATING AGENCY: National Advisory Committee for Aeronautics, Washington, D. C.
TRANSLATION:

COUNTRY	LANGUAGE	FORG'N.CLASS	U. S.CLASS.	DATE	PAGES	ILLUS.	FEATURES
U.S.	Eng.		Unclass.	Sep'42	23	19	graphs

ABSTRACT

Curves show data on amount of cargo which can be carried at various ranges and pounds of cargo which can be carried per pound of fuel. Analysis was conducted for design load factor of 4. Charts show that bomb capacity is almost entirely dependent upon power loading and that wing loading has no effect at 1000 mile range. For 1000-mile range, 15% of cargo should be fuel; for 6000 miles 58% should be fuel. Optimum power loading is approximately 25 lb/hp.

NOTE: REQUESTS FOR COPIES MUST BE ADDRESSED TO N.A.C.A., WASHINGTON, D. C.